

NESTING HABITAT AND SUCCESS OF THE CHIMANGO CARACARA IN SOUTHERN CHILE

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ABSTRACT.—We studied the nesting ecology of the Chimango Caracara (*Milvago chimango*), a common yet poorly known raptor on Chiloé Island, southern Chile, during two breeding seasons. Deforestation and land clearing in this landscape may be benefiting this raptor, which is tolerant of open and disturbed habitats and human activity. Chimangos nested at different heights in a variety of trees and shrubs, but nests were always well concealed because they were placed centrally and in dense vegetation within the substrate. Egg laying occurred in most nests in October during both years; the most common clutch sizes were 2 or 3 eggs. The incubation and nestling periods were approximately 5 (2 nests) and 6 (1 nest) weeks, respectively. Nest success (Mayfield) for 72 nests averaged 57% for the two years. Productivity averaged 1.22 ± 0.11 fledglings per active nest and did not differ between years. For nests located during both years ($n = 15$), productivity was slightly higher in 1997–1998 and more nests failed in 1998–1999. Two pairs attempted to renest after nest failure but were not successful. Habitat and landscape features associated with high productivity of chimango nests included exotic trees and shrubs, tidal flats, linear forest strips, and occupied houses or barns. Successful nesting was associated with exotic trees and shrubs. Nesting density was highest along beaches, although not all pairs that built nests along beaches laid eggs. Successful nests along beaches fledged twice as many young as inland nests. Continued clearing of the rainforest in this region may provide increased foraging opportunities for this raptor but may also result in fewer nest sites. Received 6 July 1998, accepted 24 Dec. 1999.

The Chimango Caracara (*Milvago chimango*, Falconidae, Caracarinae) is a common raptor in southern South America (Brown and Amadon 1968, del Hoyo et al. 1994). The chimango occurs in both forested and open habitats throughout its range and is frequently found around human settlements. This generalist predator has a varied diet, which includes carrion and human refuse as well as live prey such as insects, worms, and other invertebrates, small mammals, and nestling birds (Johnson 1965, Yáñez et al. 1982).

The temperate rainforest in South America is restricted to southern Chile and adjacent western Argentina and, as such, functions as an ecological island (Vuilleumier 1985). The associated avifauna is comprised of numerous endemic species, many of which are increasingly threatened by forest fragmentation (Balmford and Long 1994, Willson et al. 1994). In many areas, expanding anthropogenic influences are transforming landscapes

into patchworks of different sized forest fragments interspersed with pastures and crop fields interconnected with linear forest strips (Willson et al. 1994).

Clearing of the forest in many areas is likely to be advantageous for open habitat species such as the Chimango Caracara. The chimango apparently is tolerant of human activity (Jaksic and Jiménez 1986), and farms augment the chimango's food resources, providing poultry and earthworms. Consequently, the chimango may be benefiting from forest fragmentation by numerically responding to increases in the amount of open area resulting from forest clearing. A known predator on eggs and nestling birds (Fraga and Salvador 1986; Donázar et al. 1996; K. Sieving and M. Willson, unpubl. data), the chimango may represent an increasing threat to endemic forest birds confined to remnant forest patches and strips.

The ecology of the chimango is poorly known. Its breeding biology and nesting habitat in Argentina have been described (Fraga and Salvador 1986, Travaini et al. 1994), but the overall paucity of information on the species limits our ability to evaluate its response to land use changes or its potential role as a nest predator. Here, we report data collected during two breeding seasons on the nesting habitat and nest success of the Chimango Caracara in southern Chile.

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STUDY SITE AND METHODS

We studied the Chimango Caracara on private farms throughout northeastern Isla Grande de Chiloé, Region X, southern Chile (43° 55' S, 73° 35' W). The study area, approximately 24,000 ha, extends from the western to the eastern coasts of the island. Agriculture is the primary land use, resulting in a landscape that is a diverse mosaic of forest patches and linear strips, fields containing scattered secondary growth of trees and shrubs, open pastures, and agricultural fields. Remnant patches of forest are greatly disturbed by logging, removal of firewood, and cattle grazing; patch sizes range from less than one to several hundred hectares. Species in the canopy are broad-leaved evergreen trees. Dominant trees in these second-growth forests include canelo (*Drimys winteri*), notro (*Embothrium coccineum*), mañío (*Podocarpus nubigena*), arrayán (*Luma apiculata*), luma (*Amomyrtus luma*), and meli (*A. meli*). Scattered trees characteristic of the original primary rainforest include coigue (*Nothofagus nitida*), ulmo (*Eucryphia cordifolia*), and tepa (*Laureliopsis philipiana*). The forest understory contains few shrubs, although species of quila (*Chusquea* spp., arborescent bamboos) and tree ferns (*Lophosoria quadripinnata*) occur frequently; the bamboos form dense thickets. Shrubs, found primarily along forest edges and in open fields, include *Rhaphithamnus spinosus*, species of *Fuchsia*, *Pernettya*, and *Berberis*, and the exotic pest, gorse (*Ulex europea*). Pastures and open fields contain a variety of pasture grasses and forbs. Common trees around dwellings and cultivated areas include exotic species such as Douglas fir (*Pseudotsuga menziesii*), cypress (*Cupressus* spp.), and pine (*Pinus* spp.). The climate is temperate and humid. Annual rainfall averages 2000–3000 mm; more than one third of the total falls during the summer warm season (December through March). Air temperatures range from 5–25°C in summer and from 2–15°C in winter.

During October 1997 through January 1998 (Year 1) and again in October 1998 through January 1999 (Year 2), we searched for nests in areas where we observed chimangos. Once found, nests were checked weekly to monitor status. Nests were classified as active (with at least 1 egg laid) or inactive (where new material was added but no eggs or young were ever observed). We examined nest contents and determined clutch size, brood size, and chick age using a mirror attached to an extendible pole or by climbing the nest tree.

To evaluate breeding chronology, we divided each month into two periods, early and late (1–15 and 15 to end, respectively). We assigned clutch initiation for each of the sample nests to one of these periods, based either on the known time of egg-laying or on back dating from known hatching or fledging dates. We continued to check breeding areas with nest failures for signs of renesting.

We estimated overall nest success using Mayfield's method (Mayfield 1961, Johnson 1979) and estimated weekly nest success probabilities separately for the in-

cubation and nestling periods. We defined a successful nest as one in which at least one chick fledged. At some nests, older chicks were observed perched on branches away from the nest; we assumed that these chicks successfully fledged. We compared nest success probabilities using the program CONTRAST (Sauer and Williams 1989). Productivity was measured as the number of young fledged per active nest.

To characterize the chimango's nest sites, we recorded substrate species, substrate height, nest height, and nest orientation (compass direction) and position (central or peripheral) within the substrate for each nest found. We tested the hypothesis of no directional orientation of nests within the substrate using Rayleigh's test (Batschelet 1981). We also estimated canopy cover above each chimango nest and measured linear distances between neighboring nests.

We analyzed associations between reproductive success of the chimangos and particular habitat or other features characteristic of this human dominated and diverse landscape. From radiotelemetry, we determined that breeding chimangos generally forage within 250 m of their nest (J. Morrison, unpubl. data). For this analysis, we recorded presence or absence of certain features within 250 m of each nest we found and considered these features to be accessible to the pair occupying that breeding area. Features included: small (less than 1 ha in size) and large (>50 ha) forest patches, linear forest strips (<50 m in width), pasture, cultivated agricultural fields, exotic trees or shrubs, human activity (occupied house or barn), freshwater streams or marshes, and tidal flats.

We examined the association of reproductive success with the presence or absence of these features within 60 chimango breeding areas. Although some of the breeding areas were known both years, we used only reproductive success information for the first year in which the area was identified and a nest was found. We calculated two indices of reproductive success for each breeding area: (1) nesting success (succeeded or failed) and (2) productivity (high or low). We considered nests that fledged 2 or 3 young as having high productivity; nests with low productivity fledged only one chick or failed. We used 2 × 2 contingency tables and G-tests for independence with Yates' correction (Sokal and Rohlf 1995) to test relationships between presence or absence of these landscape features in the breeding areas and these two indices of reproductive success.

All results are presented as mean ± one standard error (SE) unless otherwise indicated. Statistical tests were conducted using SYSTAT (SPSS Inc. 1998).

RESULTS

We located 75 chimango nests in 60 different breeding areas during the two years. Because some nests were inaccessible (trees too tall or dangerous to climb) we obtained information on breeding chronology and reproductive success for only 39 and 33 nests during

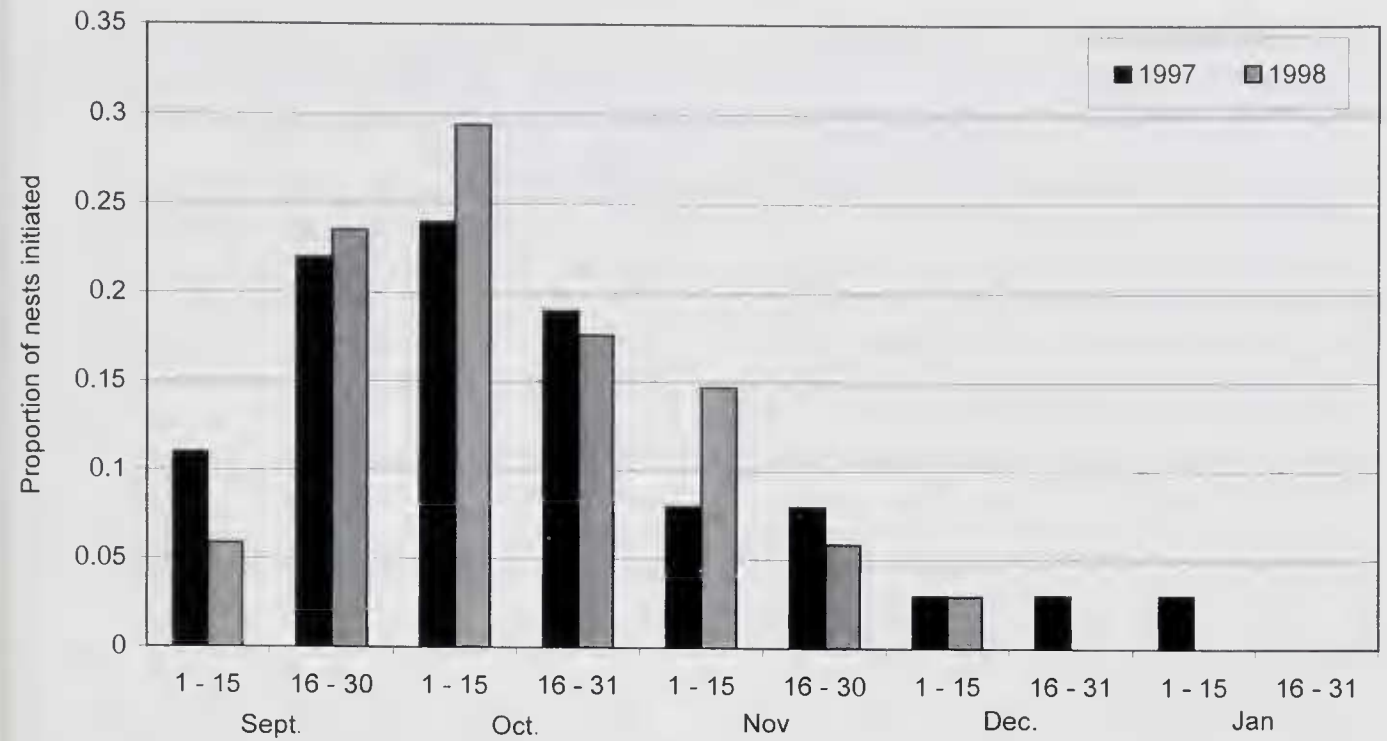


FIG 1. Initiation of egg laying in Chimango Caracara nests, Isla Grande de Chiloe, Chile, October 1997–January 1998, and October 1998–January 1999.

1997–1998 and 1998–1999, respectively. Egg-laying began in early September and peaked in early October during both years (Fig. 1). Overall, clutch size averaged 2.30 ± 0.17 (range = 1–3 eggs) and did not differ between years ($t = -0.76$, $P > 0.05$; Table 1). Each year, similar proportions of nests contained 2 and 3 eggs and only 1 nest contained a single egg (average 11% of nests). Hatching rate averaged 84% (Table 1). Overall probability of nest success to fledging for the two years was 0.57 ± 0.04 (SD) but was high-

er in 1998–1999 ($\chi^2 = 9.76$, $P < 0.01$; Table 1). Success estimates differed between the incubation and the nestling periods during 1998–1999 ($\chi^2 = 11.8$, $P < 0.001$) but not during 1997–1998 ($\chi^2 = 0.26$, $P > 0.05$; Table 1). Productivity averaged 1.22 ± 0.11 young per active nest and did not differ between years ($t = -0.53$, $P > 0.05$). For nests known during both years ($n = 15$), productivity was slightly higher ($t = 2.13$, $P = 0.05$) in 1997–1998 (1.77 ± 0.21) than in 1998–1999 (1.11 ± 0.20), and more nests failed in 1998–1999

TABLE 1. Reproductive parameters for Chimango Caracara (*Milvago chimango*) nests, Isla Grande de Chiloe, Chile during 1997–1998 and 1998–1999. Results are presented as mean and (SE) unless otherwise indicated.

	1997	1998
Total nests followed	39	33
Number of nests that successfully hatched eggs	34	30
Number of nests that successfully fledged young	28	24
Clutch size	2.38 (0.18) (n = 13 nests)	2.14 (0.26) (n = 7 nests)
Mayfield nest success probabilities (SD)		
Incubation period	0.67 (0.05)	0.73 (0.05)
Nestling period	0.70 (0.03)	0.91 (0.02)
Overall to fledging	0.47 (0.04)	0.67 (0.05)
Number fledged per territorial pair	1.26 (0.16)	1.15 (0.13)
Nest failures (%)	11 (28%)	9 (27%)

(17% vs 6% in 1997–1998). We found evidence of two renesting attempts after failure, both nests subsequently failed. In other cases where nests apparently failed, the adults remained around the nesting area, but we found no evidence of renesting.

Both sexes participated in nest-building, incubation, feeding the young, and defending the nest. The incubation and nestling periods were approximately 32 ($n = 2$) and 41 ($n = 1$) days, respectively. Pinfeathers were first visible on chicks at about 2.5 weeks of age. At about 5 weeks of age, chicks began to perch away from the nest on other branches in the nest tree. If flushed from the nest at this age, chicks flew readily and fairly easily among trees and rarely came to the ground.

Chimangos nested ($n = 75$ nests) in a variety of sites including dense forest (13%), the right-of-way of a major road (15%), open habitat containing scattered trees, shrubs, or scrubby vegetation (53%), within 100 m of an occupied house or barn (45%), and along beaches, generally also near an occupied house or barn (15%). Chimangos used a range of nesting substrates of varying heights, including native and exotic trees and shrubs, and snags (mean substrate height $12.2 \text{ m} \pm 0.8$, range 3.4–28.9 m, $n = 75$ nests; Table 2). Chimangos tended to place their nests near the central part of the substrate (69% of all nests) and under dense canopy cover ($71.8\% \pm 2.7$, $n = 73$ nests; Table 2). Nests showed a slight directional orientation but angular dispersion was high (mean = 63° , Rayleigh's $R = 15.61$, $s = 101^\circ$, $n = 74$, $P < 0.05$; Table 2).

Breeding chimangos exhibited behaviors typical of other territorial raptors. They were highly aggressive near the nest and pairs often stooped and attacked us when we climbed nest support structures. Other chimangos in particular were attacked and rapidly chased away from the nesting area. Despite this apparent intolerance of conspecifics, we found chimango pairs nesting quite close together at some sites. Adjacent pairs nested closer together ($t = -2.40$, 17 df, $P = 0.03$) along beaches ($170 \text{ m} \pm 30 \text{ m}$, range = 60–180 m, $n = 5$ pairs) than inland ($470 \text{ m} \pm 70 \text{ m}$, range = 40–1070 m, $n = 14$ pairs). At one beach site, we found 3 pairs building nests in a line of exotic cypress trees approximately 100 m in length. Only one of these pairs successfully raised

chicks. The other pairs never laid eggs, although they remained in the area and continued adding nest material to the structures through January.

Tests of association between landscape features and productivity indicated that high productivity (29 of 60 nests) was positively associated with exotic trees or shrubs, linear forest strips, and tidal flats and perhaps with human activity (Table 3). Productivity in breeding areas along beaches (2.14 ± 0.26 , $n = 9$) was higher ($t = 3.48$, 12 df, $P < 0.01$) than productivity of inland breeding areas (1.06 ± 0.17 , $n = 51$). Successful nesting was associated with exotic trees and shrubs (Table 3).

DISCUSSION

The chimango is the most common bird of prey on Chiloé, perhaps in all of Chile. It can be observed regularly in all habitats and particularly in those occupied by humans. Large groups of chimangos (>50) were often seen along beaches, in pastures, and on edges of towns.

Breeding chronology of chimangos in our study area was similar to that reported for chimangos nesting in Argentina (Fraga and Salvador 1986). In their study areas in Buenos Aires and Córdoba provinces, Fraga and Salvador (1986) found nests with eggs from the end of September through December with a peak of egg laying in October. They also reported larger mean clutch sizes (2.76 ± 0.43) but a shorter incubation period (26–27 d) for chimangos nesting in their study areas than we noted for chimangos nesting on Chiloé. Fraga and Salvador (1986) reported nest success of 30% for chimangos in their study area and indicated that many nests were lost to predation.

Weather on Chiloé can be inhospitable and undoubtedly has played an important role in the evolution of the chimango's reproductive biology. The chimango's low nest success on Chiloé may be attributed to wind and rainstorms which are common on Chiloé and may cause nest failures. Nest failure also could be due to nest predation, perhaps by conspecifics. We regularly observed territorial behavior by breeding pairs, including 4 or more chimangos chasing and fighting within breeding areas, often near active nests.

TABLE 2. Summary of nest site characteristics for 75 Chimango Caracara (*Milvago chimango*) nests, Isla Grande de Chiloé, Chile, 1997–1999. Values are mean and (SE).

Tree species	n nests	Substrate height (m)	Nest height (m)	Nest position relative to substrate top (%)	Nest orientation (°)	Nest position within substrate ^a	Canopy coverage above nest (%)
<i>Acacia melanoxylon</i> ^b	1	7.9	6.4	81	100	1	55
<i>Anomyrtus huna</i>	2	9.4 (1.5)	8.4 (1.9)	88 (0.1)	185	1-1, 1-2	77.5 (17.5)
<i>Aracaria araucana</i>	1	13.7	13.1	96	218	2	60
<i>Cupressus</i> spp. ^b	9	22.0 (1.8)	14.9 (1.9)	68 (0.1)	54	4-1, 5-2	71.1 (7.3)
<i>Drinys winteri</i>	2	9.3 (0.2)	8.4 (0.2)	90.0 (0.0)	48	1-1, 1-2	65 (5.0)
<i>Eucryphia cordifolia</i>	6	10.8 (1.5)	9.6 (1.4)	88.0 (0.0)	274	2-1, 4-2	81.3 (8.5)
<i>Laureliopsis philipianae</i> ^c	2	13.9 (2.6)	9.1	81	278	1-1, 1-2	45 (0.0)
<i>Luma apiculata</i>	10	8.6 (1.2)	7.3 (1.2)	82.0 (0.0)	135	3-1, 7-2	66.5 (8.4)
<i>Malus bacatta</i> ^b	1	9.1	7.3	80	170	1	40
<i>Pilgerodendron uviferum</i>	1	3.4	2.3	68	75	1	25
<i>Pinus</i> spp. ^b	8	21.4 (1.8)	16.5 (2.0)	77 (0.1)	68	2-1, 6-2	67.5 (9.2)
<i>Podocarpus nubigena</i>	15	8.1 (0.7)	7.0 (0.7)	86.0 (0.0)	66	12-1, 3-2	83.5 (4.8)
<i>Pseudotsuga menziesii</i> ^b	8	13.3 (1.2)	10.4 (0.9)	78.0 (0.0)	166	7-1, 1-2	87.3 (5.0)
<i>Rliaphthannus spinosus</i>	7	6.6 (1.0)	4.7 (0.8)	70.0 (0.0)	161	2-1, 5-2	61.4 (6.4)
snag, species not known	2	9.3 (1.7)	7.9 (0.9)	86.0 (0.1)	310 ^d	—	50 ^e

^a Nest position: 1 = central to the substrate, such as along the main stem or trunk; 2 = peripheral within the substrate, such as out on a branch away from the main stem or trunk.

^b Exotic species.

^c One nest tree of this species was in dense forest, thus we could not measure variables other than substrate height.

^d Measured for 1 nest only. The other nest was in the open, broken top of the snag so nest orientation and nest position within substrate were not measurable.

^e Canopy cover for the nest inside the snag was 100%, for the nest in the broken top snag, 0%.

TABLE 3. Results of tests of association between landscape features and indices of reproductive success of Chimango Caracaras on Isla Grande de Chiloé, Chile. The total number of nests used for this analysis was 60; *n* is the number of breeding areas having each variable.

Feature	<i>n</i>	Nest productivity <i>P</i>	Nest success <i>P</i>
Small forest patch	37	>0.05	>0.05
Large forest patch	8	>0.05	>0.05
Pasture	58	>0.05	>0.05
Exotic trees or shrubs	30	<0.01	<0.01
Cultivated agricultural fields	29	>0.05	>0.05
Human activity	50	>0.05	>0.05
Freshwater streams or marshes	21	>0.05	>0.05
Tidal flats	9	0.01	>0.05
Linear forest strips	42	0.04	>0.05

While successful nesting by chimangos in this landscape could be associated with features other than those we measured, we believe that the apparent lack of association between most of these features and successful nesting as shown by our results further suggests nest predation as a potential cause for nest failure in this population.

Although nest success estimates for chimangos in our study area were higher than estimates reported by Fraga and Salvador (1986), actual nest success of chimangos on Chiloé may be lower than our results suggest. Of nests known during both years, more failed in 1998–1999 than in 1997–1998, perhaps suggesting that we mostly found successful nests. We could have missed nests that failed during egg laying or early in the incubation period, particularly if predation risk to nests is high.

Although we did not find chimangos nesting on the ground as has been reported elsewhere (Fraga and Salvador 1986, Travaini et al. 1994), chimangos on Chiloé nested in a wide variety of sites and often near human activity. Heights of substrates used for nesting by chimangos in our study area were taller on average than those reported elsewhere (Fraga and Salvador 1986, Travaini et al. 1994). This difference may reflect the availability of different woody species as potential nesting sites on Chiloé, particularly exotic trees such as cypress and pine. Although we found a significant orientation in the direction of the nests, as did Travaini and coworkers (1994), we also observed a great deal of scatter. Chimangos

on Chiloé tended to nest near the protected, central place of the substrate and under dense canopy cover. Such placement may provide maximum protection from inclement weather and may also reduce predation risk.

We did not observe semicolonial nesting of chimangos on Chiloé as has been reported elsewhere (Fraga and Salvador 1986); however, we found pairs nesting as close together as 40 m in some areas, particularly along beaches. Fraga and Salvador (1986) suggested that semicoloniality of chimangos at their study sites was due to spatial and temporal variation in food resources rather than lack of nest sites. On Chiloé, high nest productivity and nesting density along beaches suggest that these areas provide good habitat and abundant food resources for the chimangos.

The wide variety of nesting sites used by chimangos on Chiloé may be a consequence of a high density of this species in the study area or a lack of specific nesting requirements. Conversely, it could be argued that continued clearing of land for housing and farms on Chiloé may be resulting in loss or altered availability of nest sites for the chimangos. Selection for a particular nesting situation may be obscured by habitat saturation or nest site limitations that would restrict nesting possibilities. Especially along beaches, competition for both nest sites and food was suggested by the fact that some pairs built nests but never laid eggs and by frequently observed chasing and fighting among pairs.

Studies have shown that the density of generalist predators increases as a forested land-

scape becomes fragmented and interspersed with agricultural land (Whitcomb et al. 1981, Andrén 1992). Our results suggest some association between high productivity and success of chimango nests and features that reflect the human presence in the current landscape on Chiloé including exotic trees and shrubs, linear forest strips, and occupied houses or barns. The thick branches and dense crowns of exotic trees such as cypress and pine may provide better protection from weather or from predators, perhaps explaining the association of this variable with successful nesting. Around human dwellings exotic trees and shrubs are often the only species present because most of the landscape has been cleared for pasture or crops. Rather than reflecting selection for these exotic species, their use by nesting chimangos instead may reflect the availability of suitable nest sites or selection of a site near food sources (farms). The association of forest strips with high nest productivity may reflect the proximity of these strips to pasture. Alternatively, forest strips have relatively large amounts of edge and thus may provide more foraging opportunities for the chimangos, which are known to prey heavily on bird nests in edge habitats (M. F. Willson, J. L. Morrison, K. E. Siving, T. L. De Santo, L. Santistehán, and I. Díaz, unpubl. data).

The chimango caracara is a generalist predator associated with landscapes impacted by humans. On Chiloé, the chimango's apparent tolerance of humans, generalist diet, and use of open habitats may increase the species' potential both as a nest predator on forest birds and as a pest to local landowners. Continued forest clearing and expansion of human activity on Chiloé will likely improve foraging opportunities for the chimango. Conversely, continued clearing of land may lead to increased competition for nest sites or higher predation on chimango nests.

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